Vol. I.] DECEMBER, 1901. [No. 7.

# School Science

A Journal of Science Teaching in Secondary Schools.

EDITED BY C. E. LINEBARGER.



## CONTENTS.



(*Continued on page 2 of cover.*)

SCHOOL SCIENCE, Room 1318—138 Washington St., CHICAGO.

*Published Monthly, September to May Inclusive.*

**Price $2.00 Per Year. 25c. Per Copy.**

*Entered at the Post Office in Chicago, Ill., as Second-Class Matter.*

School Science

VOL. 1] DECEMBER, 1901. [NO. 7

# THE APPLICATION OF STATISTICS TO EVOLUTION STUDIES.

BY CHAS. B. DAVENPORT.
*Professor of Zoology, University of Chicago.*

As an illustration of an application of statistics to evolution studies I will give some account of my work during the past two years on the scallop of our east coast, *Pecten irradians.*

*Pecten irradians* is a bivalve mollusc of flattened, lenticular form, that inhabits our coast from Cape Cod southward. The Cape Cod limit is a rather sharp one, but southward our scallop passes gradually into the closely related forms of the South American coast. This fact would seem to indicate its southerly origin. To get light on the evolution of the group, I have studied and measured over 3,000 shells, chiefly from four localities: (1) Cold Spring Harbor, Long Island; (2) Morehead, North Carolina; (3) Tampa, Florida, and (4) the late Miocene or early Pliocene fossils of the Nansemond River. The fossil shells, to which I shall frequently refer, were found imbedded in the sand at Jack's Bank, one mile below Suffolk, Virginia. The bank rises to a height of 25 to 30 feet. Shells were obtained from three layers, respectively, one foot, six feet and 15 feet above the base of the bluff. Of course, the upper shells lived later than the lower ones and may fairly enough be assumed to be their direct descendants. The time interval between the upper and lower levels cannot be stated. As I have measured sufficient shells from the bottom

and top layers only I shall consider them chiefly. I wished to get recent *Pectens* from this locality, but the nearest place where they occur in quantity is Morehead, North Carolina. These *Pectens* may therefore stand as the nearest recent descendants of the *Pectens* of the Nansemond River.

The *Pecten* shells have a characteristic appearance in each of the localities studied. After you have handled them for some time you can state in 95 per cent. of the cases the locality from which any random shell has come. First of all, the shells differ in color, especially of the lower valve. In the specimens from Cold Spring Harbor this is a dirty yellow; from Morehead, yellow to salmon; from Tampa, white through clear yellow to bright salmon. Second, the antero-posterior diameter of the shell becomes relatively greater than the vertical diameter as you go north. Thus, the antero-posterior diameter exceeds, on the average, the dorso-ventral diameter: at Tampa, by about 1.5 mm.; at Morehead, 2.5 mm.; and at Cold Spring Harbor, 6 mm. The fossil *Pectens* have an excess of about 4 mm.

Comparing the fossils with the *Pectens* of Morehead we find, as shown above, that the fossils are more elongated. Comparing the depth of the right valves having a height of 59 mm., we get:

| | |
|---|---|
| From the lowest level, Jack's Bank | 8.8 mm. |
| From the highest level, Jack's Bank | 9.1 mm. |
| From Morehead | 19.7 mm. |

Hence the recent shells are much more nearly spherical than the fossils; there is a phylogenetic tendency toward increased globosity.

The average number of rays in the different localities is as follows:

| | |
|---|---|
| Lower level, Jack's Bank | 22.6 |
| Middle level, Jack's Bank | 22.1 |
| Upper level, Jack's Bank | 21.7 |
| Morehead and Cold Spring Harbor | 10.3 |
| [Tampa | 20.5] |

Here it appears that there is a phylogenetic tendency toward a decrease in the number of rays of *Pecten irradians*. To summarize: The scallop is becoming, on the average, more globose,

and the number of its rays is decreasing and its valves are probably becoming more exactly circular in outline. The foregoing examples illustrate the way in which quantitative studies of the individuals of a species can show the change in its average condition both at successive times and in different places.

But the quantitative method yields more than this. It is well known that if the condition of an organ is expressed quantitatively in a large number of individuals of a species the measurements or counts made will vary, *i. e.,* they will fall into a number of *classes.* The proportion of individuals falling into a class gives what is known as the "frequency" of the class. Now it appears that in many cases the middle class has the greatest frequency (and is consequently called the mode) and as we depart from it the frequency gradually diminishes, and diminishes equally at equal distances above and below the mode. One can plot the distribution of frequencies by laying off the successive classes at equal intervals along a base line and drawing perpendiculars at these points proportional in length to the frequency. If the tops of these perpendiculars be connected by a line there is produced a 'frequency polygon.' The shape of the frequency polygon gives much biological information. When the polygon is symmetrical about the modal ordinate we may conclude that no evolution is going on; that the species is at rest. But very often the polygon is more or less unsymmetrical or 'skew.' A skew polygon is characterized by this: that the polygon runs from the mode further on one side than on the other. This result may clearly be brought about by the addition of individuals to one side or their subtraction from the other side of the normal frequency polygon. The direction of skewness is toward the excess side. The skew frequency polygon indicates that the species is undergoing an evolutionary change. Moreover, the direction and degree of skewness may tell us something of the direction and rate of that change. There is one difficulty in interpretation, however, for a polygon that is skew may be so either from innate or from external causes. In the case of skewness by addition we may think that there is an innate tendency to produce variants of a particular sort, representing, let us say, the *atavistic* indi-

viduals. In this case skewness points to the past. The species is evolving *from* the direction of skewness. In the case of skewness by subtraction there are external causes annihilating some of the individuals lying at one side of the mode. Evolution is clearly occurring away from that side and *in* the direction of skewness.

Now so far as we know at the present time there is no way of distinguishing skew polygons due to atavism from such as are due to selective annihilation. But in many cases at least the skewness, especially when slight, can be shown to be due to atavism; and this is apparently the commoner cause. This conclusion is based first upon a study of races produced experimentally and whose ancestry is known, and secondly upon certain cases of compound curves. Take the case of the ray flowers of the common white daisy. A collection of such daisies gathered in the fields by De Vries gave a mode of 13-ray flowers with a positive skewness of 1.2. The 12- or 13-rayed wild plants were selected to breed from, and their descendants, while maintaining a mode at 13, had the increased positive skewness of 1.9. The descendants of the 12-rayed parents had a stronger leaning towards the high ancestral number of ray flowers than the original plants had. The 21-rayed plants were also used to breed from. Their descendants were above the ancestral condition as the descendants of the 12-rayed plants were below. The skewness is negative (—0.13) although comparatively slight. In this case we have experimental evidence that polygons may be skew *toward* the original ancestral condition.

Of the compound polygons it is especially the bimodal polygon that frequently gives hint of two races arising out of one ancestral, intermediate condition. Consequently we should expect the two constituent polygons to be skew in opposite directions; and so we usually find them to be. For example, Bateson has measured the horns on the heads of 343 rhinoceros beetles and has got the bimodal polygon. The polygon with the lower mode has a skewness of $+0.48$; that of the higher mode a skewness of $-0.03$. One might infer that the right-hand form, the long-horned beetles, had diverged less than the short-horned from the

ancestral condition. Again, as is well known, the chinch bug occurs in two forms—the long-winged and the short-winged. Now, in a forthcoming paper my pupil, Mr. Garber, will show that the frequency polygon of the short-winged form has a skewness of $+0.44$, while that of the long-winged form has a skewness of $-0.43$. On our fundamental hypothesis the ancestral condition must have been midway between the modes.

Still a third class of cases that gives evidence as to the significance of skewness is that where two place modes have moved in the same direction, but in different degrees. Thus the index (breadth $\div$ length) of the shell of *Littorina littorea,* the shore snail, as measured by Bumpus ,has at Newport a mode of 90, at Casco Bay, of 93. The skewness is positive in both places and greater ($+.24$) at the more southern point than at Casco Bay ($+.13$). This indicates that the ancestral races had a higher index than even those of Casco Bay, probably not far from 96, and also that the *Littorina littorea* of our coast came from the northward, since the northern shells are the rounder. We have historical evidence that they did come from the northward. Likewise the *Littorinas* from South Kincardineshire, Scotland, have a modal index of 88 and a skewness of $+0.065$, while those of the Humber, with a mode of 91 have a skewness of $+0.048$ These figures suggest that if the mode were 97 the skewness would be 0, and this would give practically the same value to the ancestral index, as arrived at from the *Littorinas* of our coast. It will be seen from these illustrations that the form of the frequency polygon may be of use in determining phylogeny.

While skewness is thus often reminiscent, we must not forget the possibility that it may be, in certain cases, prophetic. This has come out rather strongly in a piece of work I have been engaged on during the past year. I have been counting the number of rays in recent *Pecten irradians* from various localities and have obtained in some cases evident skewness in the frequency polygons. To see what phylogenetic meaning, if any, this skewness has, I sought to get a series of late fossils. After careful consideration I was led to go to the Nansemond River for the late Tertiary fossils found there and already referred to. These

served my purpose admirably. We may now compare the average number of rays from the two extreme layers at Jack's Bank and at Morehead with the indices of skewness of the frequency polygons from the same localities.

| PLACE | AV'G NO. OF RAYS | INDEX OF SKEWNESS | *s* |
|---|---|---|---|
| Morehead, N. C. ........... | 17.3 | —0.09 | 0.81 |
| Upper Layer, Jack's Bank | 21.7 | —0.16 | 1.0 |
| Lower Layer, Jack's Bank | 22.6 | —0.22 | 1.24 |

This series is instructive in that it tells us that the gradual reduction in the number of rays has been accompanied at each preceding stage by a negative skewness. This skewness was thus *prophetic* of what was to be. The skew condition of the frequency polygon we may attribute to a selection taking place at every stage, and the interesting result appears that the selection diminishes in intensity from the earliest stage onward. It is as though perfect adjustment were being acquired. If adjustment were perfected, we might expect a decrease in the *variability* in the rays at successive periods. And we do find such a decrease. This is indicated in the last column where *s* stands for the index of variability. From this column it appears that the variation in the number of rays has diminished from 1.24 rays in the Miocene to 0.81 rays in recent times. This fact again points to an approach in perfection and stability on the part of the rays. Just why or wherein the reduced number of rays is advantageous I shall not pretend to say. It is quite possible that it is not more advantageous, but that there is in the phylogeny of *Pecten irradians* an inherent tendency towards a reduction in the number of multiple parts. As a matter of fact there are other *Pectens* in which the number of rays is less even than in *irradians*.

The reduction in the variability of the rays with successive geological periods has another interest in view of the theory of Williams and of Rosa, according to which evolution and differentiation have of necessity been accompanied by a reduction in variability. Evolution consists, indeed, of a splitting off of the extremes of the range of variation, so that in place of species with

a wide range of variability we have two or three species each with a slight range of variability. In the particular case in hand, however, it is not certain that the lower Jack's Bank form-unit (named *Pesten eboreus* by some one) has given rise to any other form than something of which *Pecten 'irradians'* of Morehead is a near representative. The evidence indicates that the reduced variability is solely the effect of the skewing factors.

The upshot of this whole investigation into the biological significance of skew variation is then this: Skewness is sometimes reminiscent and sometimes prophetic. In our present state of knowledge it is not possible by inspecting a single skew curve to say which of the two interpretations is correct in the given case. But by a comparison of the frequency curves of allied form-units the state of affaairs can usually, as in the examples given, be inferred. A method of interpreting the single skew curve is a discovery for the future.

---

## ASTRONOMICAL OBSERVATIONS IN GEOGRAPHY.

BY JOHN M. HOLZINGER.
*State Normal School, Winona, Minn.*

Efforts to improve the teaching of geography in the elementary public school have been numerous and varied among us. Nor does the present exhibit any abatement of them. The present tendency, however, seems to be setting strongly in the direction of physical geography. This paper is confessedly an effort to show that more observational work should be done in the teaching of what may be termed astronomical geography.

Probably the strongest argument for such work is to be drawn from the almost uniformly unsatisfactory answers given by high-school graduates to geographical questions involving a concrete knowledge, as opposed to a verbal knowledge, of such easily demonstrable facts as the earth's daily motion on its axis. Correct mental images of the earth as a sphere, and of the position

of the plane of the observer's horizon in all latitudes, are not derivable from the committing of the formal phrases and diagrams of a book. Certainly not one student in a hundred who has been taught geography according to present methods is able to imagine for himself with any degree of adequacy the dependence of daily phenomena upon the observer's latitude—and is this not quite as valuable to him as the commonly current dallying with the papooses of the Esquimaux? It would seem that the connection of such facts as the latter typifies with the latitude, although real enough, are too accidental, not to say silly, to justify the time commonly spent upon them.

Of course we teach how to compute the position of the sun relative to the horizon in different latitudes. Perhaps we even draw diagrams showing the decrease in the daily total of calories as we pass northward in latitude. But the proof that all this remains mere words, wholly inconvertible by the pupil into anything like a panorama, is found in the well-nigh unformly incorrect answers to questions concerning phenomena within the arctic circle. Let the problem be set. In a place having three months of consecutive daylight and three months of consecutive night, what circumstances as to light and darkness prevail during the remaining six months? The common answer will be, "The remaining six months are twilight" Generally, though not always, these six months of twilight are said to occur in two periods of three months each, one previous to, and the other subsequent to, the "long night." The palpable ignorance here shown of the most fundamental and regular daily occurrence, or perhaps better, the absolute inability to apply what every child must know full well as a verbal statement; viz., the earth's rotation, is incredible to any one not familiar with the facts.

How can this and similar evidences of ignorance be at least measurably remedied? In the writer's opinion the only way out of the difficulty lies through simply observing for a period of years during the later grades and high school the more obvious phenomena of the daily and nightly sky.

To carry this out it is quite unnecessary that the pupils should do their star-gazing in groups. The better plan is to draw upon the board, a few at a time, some twelve or fifteen simple diagrams

of star-groups to be used by the pupils as a guide in their surveys of the heavens. Pupils copy these diagrams and identify and verify them from their homes. The objective point of this work is to familiarize the pupil with the star-groups which mark the constellations of the zodiacal belt. And within certain limits it may almost be said that the fewer stars selected in each constellation the better. For elementary pupils the names of the individual stars is a matter of no consequence. The writer requires his pupils to learn the names of the first and a few second magnitude stars; not over twenty in the entire heavens visible in latitude approximately 40° N.

Thus, "three stars" mark Arias, Pleiades and Aldebaran, Taurus, Castor and Pollux, and Tejot (the only third magnitude star learned by name), Gemini; "four faint stars and a cluster," Cancer; "the Sickle, and the right-angled "Triangle with Denebola," Leo; "Spica," Virgo; "four stars," Libra; "Antares and its two companions," Scorpio; "the five stars of the inverted dipper," Sagittarius; "two stars, the upper apparently double," Capricornus; "the four stars of the Y," Aquarius; "the Pentagon," Pisces.

Of the constellations north of the belt, only the following are really valuable as guides to the zodiacal groups: 1. Polaris; 2. The Great Dipper; 3. Cassiopeia; 4. Vega in the Lyre; 5. The Northern Cross in the Swan; 6. "Altair and its two companions" in the Eagle; 7. Arcturus in Boötes; 8. "Capella and the Kids" in Auriga; 9. The Square of Pegasus; 10. "Two stars" in Andromeda; 11. Algenib and Algol in Perseus.

In the space south of the zodiacal belt we learn only the following: 1. Orion, by noting Betelguese, Bellatrix, Rigel, Saiph and the yard stick, or Belt; 2. Sirius; 3. Procyon.

With these objects definitely known in relation to each other, after a year of *occasional lessons*—one or two a month are sufficient—the mapping of the place of the moon and of the visible planets with reference to the nearest zodiacal star group or groups, from night to night, becomes a delightfully interesting and profitable exercise. The discussion of the observations, of course, falls always on a morning after a cloudless evening, and should constitute a part of the geography recitation.

The result of these observations is a fairly good, because a *concrete,* understanding of the following points: 1. The line of the moon's path among the stars; 2. The dates of its nodes, determining two points in the sun's apparent path, and so the earth's real path; 3. The rising and setting, and constant westering of *all* fixed stars every twenty-four hours; 4. The *eastward* course of the moon at the rate of 13° (about), and of the sun at the rate of 1°, every twenty-four hours; 5. The determination of the point of the winter solstice a few degrees west of the handle of the Little Dipper in Sagittarius, 28° *west* of the *constellation* Capricornus, and of the point of the summer solstice, at Tejat, 28° west of the constellation Cancer, showing the *fact* of the discrepancy between signs and constellations (the *fact* of precision, not the *theory,* at first); 6. The determination of the angles which the sun's rays make at midday with our horizon on the cardinal dates of the year.

After a few lunations have been observed and mapped by nights (each map, of course, is to be accompanied by data; *hour, day* and *month* of observation), the pupil has for the first time a concrete illustration of the *way* and *direction* of the sun in its apparent annual path among the stars. Never mind, at first, the problem of the nodes, and the 5° of inclination of the planes of the orbits of the earth and moon. It is quite enough, to begin with, that the student learn, by *his own observation,* that the moon travels *eastward* from night to night, in spite of its regular setting beneath our western horizon. That it travels at the rate of about 13° daily, he may be taught to deduce from his observations. And this fact, of having in addition to the "yard stick" a measure of *angular* distance across the heavens, becomes gradually a very helpful element in the observations. The apex of the angles in geometry is *objective,* so to speak, on paper; the apex of the angles, or degrees which we say lie between two celestial objects, is *subjective,* that is, in the eye, of the observer. And here also lies a much neglected opportunity, both in geometry and geography, that of cultivating the habit of correct imaging of angles. The ability to estimate the values of angles in terms of degrees is very necessary in expressing distances between the stars.

It seems quite superfluous to point out the obvious fact that the stars, by observing which we are helped to think rightly the phenomena of the earth's rotation and revolution, are always spread out before us at the time of greatest leisure, and may with little effort be satisfactorily observed and understood by young and old alike, from one's very doorsteps; while the data of physical geography, possessing also unquestioned educational value, are acquired effectively at best by a comparatively small number, and with considerable labor and exertion in studying the absolutely insignificant area in their vicinity, as a preparation for the elementary appreciation of the laws and forces that have fashioned the whole of the earth's surface. In both cases, it is generally admitted that effective thinking is possible for the majority only on the basis of observation. But whereas in physical geography only the most insignificant portion of the earth's surface is readily studied, in astronomical geography the great panorama of the heavens may be taken in almost entire with little physical effort. And it seems almost useless to think out the earth's two motions and the resultant phenomena without such observations.

There is also another class of observations which the children and teachers of every school should make each year with scrupulous regularity, viz.: of the *sunrise point,* and the *sunset point* at the cardinal dates. Let this be done, watch in hand, on the first cloudless morning and evening nearest each date; if done a day or two before, repeat it on or right after the date. For this it is best to agree upon some common spot, preferably the school house grounds, or a second story recitation room from which sunrise and sunset can be observed. The actual determination of the angle made at the place of the observer by the shifting of this point from December to March, and to June, in degrees, is as simple as the measuring of a line; we use a Prang triangle (10 cts.), which should be possessed by every student and teacher of geography. This, as much as any exercise, will aid in the right imaging of the actual space relations of the observer, standing on the arctic circle, and of the sun, during the twenty-four hours of June 21, and as well farther north.

Some of the most important facts of geographical knowledge are the cardinal dates, the cardinal points, the lines of latitude and

of longitude, the decrease pole-ward of the sun's heat, and the effect of this changing condition upon human existence in high as well as low latitudes. An effective understanding of them by the verbal textbook method, if not quite impossible, is yet exceedingly difficult with the great majority of young minds. And the removal of this difficulty lies, according to the conviction of the writer, in the direction of the simple observations suggested.

---

## TRAINING FOR THE STUDY OF CHEMISTRY.

H. R. CARVETH.

*Instructor in Physical Chemistry, Cornell University.*

Alchemy was the old study; chemistry is the new science. Before the latter could develope, experimentation was necessary. Experiments gave rise to facts. As the facts in the field of knowledge accumulated, it became necessary to classify and correlate them. The systematic arrangement and the development of relationships led to exact theory, the basis on which this science, as all others, now rests.

In experimental work there appears the general tendency for a great number of workers to be satisfied with a very restricted view of the subject, while the general perspective presents itself only to the few who by dint of genius and hard work have refused to be satisfied with the ordinary point of view. The latter in looking around should be able to discover the general position of the science, the points open to successful attack, or the positions which must be abandoned at the first severe onslaught of opponents. In a world and an age where lack of aggressive attack shows weakness of position or a feeble initiative, no leader of men can stand at ease, for the younger, more active and more restless elements are always eager to move and to feel that they are mov-

ing. They do not always demand a change of position, but desire progress and a different view of the territory already occupied and the successes already achieved.

To this restless element, then, to those who have been studying the strides made in chemistry in the past few decades, the question presents itself: In what way has the modern spirit of research with its new facts and new theories affected the presentation of the subject to those who wish to study it? If we admit that it takes a considerable period of time for the most carefully tested of modern views to find acceptance among teachers of teachers, we must not complain if the point of view of a university teacher is not that of the college or school man. The importance of the new fact or theory, its bearing on the previously accepted, the method or place of presentation, the interests of the hearers, and the immediate utility are all points which must be considered in the development of any science.

Of the older school of chemists, many, but not all, insisted on two points in their teaching work: the student must learn facts and he must learn methods. The great and omnipresent "Why?" was apparently not dwelt upon with so great an emphasis as now. In the first half of the nineteenth century, chemistry was taught by teachers of physics, anatomy, mineralogy, etc., as a secondary subject of little importance. It was in the experimental stage. Very few of its devotees could defend their claims that it was a *science*. The broadness, however, with which it was being presented and its connection with these other subjects has laid its foundations strong and sure. At a later date there came a change. Rapid development in all lines of applied work required specialists who were soon supplied by the universities. Specialization produced a separation from the study of botany, geology, anatomy, etc. There was, therefore, to be given to it a special method of pedagogy of which, unfortunately, the keynote as above sounded seems to have been facts, facts, facts—nothing valuable but facts.

The study then became restricted to a study of the changes of form and reactions of matter, the study of their properties serving mainly for analytical purposes. The accurate study of the physical

properties and the energies involved in reactions were ignored, since the specialization methods did not allow of development along the line to which so little interest was attached.

This accumulation-of-facts method was supplemented by a study of the methods employed by the chemist. Most of these had good foundation, their originators having understood more or less the underlying principles. The students, however, used these as many an artisan uses his tools—without stopping to think whether this tool was better than another, and if so, why. As illustration, we may take distillation work in the laboratory. Any one who has to deal with any chemical work knows that one of the most important means of separating compounds is by distillation; yet as a personal opinion, the writer would state his belief that not five per cent of the chemists of this or any country trouble their heads as to whether they are getting even respectable results for their labors when performing a distillation. Time is evidently not an asset. Methods then developed into rule receipts, such as are used in every chemical factory in the world. This is a result which will disappear only when the spirit of critical analysis is more thoroughly disseminated.

The effect of such methods of presentation shows itself on the teachers, but in a way far worse where the students are concerned. The walking-encyclopedia method can be adopted and used by those who have to do so, but the results are soon to be recognized in the attitude of the students toward the subject. Should they regard it as a bore, something which is studied because it is required, or even because it will give them a few extra facts which will teach them how to make explosive mixtures, flash powders, odorous bodies or other substances which the mischievous love to handle or the ingenious dare to make, the logical conclusion is that the teacher himself has not any idea of the subject being other than a bundle of facts, much less a science.

But how many teachers of today understand the problems of the science they try to present? How many know the laws and theories they endeavor to explain? How many understand the relationship of chemistry to the other branches of science? Do any ever stop to question whether it is an exact science?

These questions present themselves to all teachers and the replies as given by pupils themselves indicate that the old method of "facts only" persists and will persist. But what is the objection, what the difficulty, and what the hope of the future?

The problem is that chemistry has advanced from the stage where it studies reaction products alone, and has reached the position where the reaction itself is studied. How the reaction may be varied and studied in all possible variations is now one of the fundamental objects of chemistry. Chemists, like all other scientists, have to deal with varying conditions. They must know how to control conditions, if their work is to be successful.

What are some factors that they can vary? As chemists, they can always vary the material they start with—its nature and its amount. If, for example, they wish to make two grams of zinc sulphate, they take twice as much of the original material (e. g., zinc and sulphuric acid) as when only one was to be made; but should they wish to make zinc chloride, it is necessary to start with other materials, such as zinc and hydrochloric acid. This general plan is the one followed by men of the older school, and they certainly deserve all credit for their wonderful work and more wonderful results in producing new materials of strange properties and reactions. But other factors have to be taken into account. The chemist must know how to vary the conditions of temperature, pressure, light, magnetic field, electro-motive force, etc., in order to produce the results at which he aims. Should he wish to effect certain reactions—as the burning of sulphur in air—he must heat the sulphur, or should he wish to preserve liquid air he must cool it. Perhaps some hydrated salts cannot be preserved without efflorescing or some liquid kept in tubes gives rise to explosions. The pressure relations should then be examined. The compound may be decomposed by light of certain wave length, but stable under other conditions. The study of the rotation of a ray of light passing through the substance when it is maintained in a magnetic field may give him a clew as to some of its other properties. All the powers which he can command to produce variations, or hold conditions constant if he so desires it, must be at his command. The workshop holds now more tools,

all of which he should know how to handle. All chemical work is embodied in the work of variation, which, to produce the best results, must be performed very intelligently. If, knowing his tools and his material, he can foresee the results of his labors, he is fast reaching the goal of the chemist's ambition.

This intimate knowledge of the working value of these various implements which he will use requires the study of physics and of chemistry. If he did not know the values, he would not be able to reproduce or control the methods with which he works. The determination of values is therefore one of the problems that will confront him daily. The accuracy, importance, method, and theory of measurements must be thoroughly understood, before a real grasp of the value of work can be obtained. For much of this work, physics must be appealed to. Wherever the composition of matter is concerned, however, the chemist is concerned.

His training in his own subject should be such, therefore, as will enable him to be master of this field. The principles of variation in the occurrence, composition, formation and reaction of bodies should be familiar to him. If all teachers of chemistry were trained merely in some especial line of work such as agricultural, analytical, pharmaceutical, etc., chemistry, what would be the result if at the same time they were not given a broad training in the other divisions of the science? Would the object of chemistry appear the same to an organic chemist, with his study of the constitution of bodies and class reactions, as to that analyst whose main motive is the detection of the kinds and amounts of bodies present in a mixture? If, in addition to a broad training in the various branches, there is added a special course of study on problems where the application of principles is required, the student should know well the underlying principles of his subject.

But physics is not alone in being closely related to chemistry. The fact that relations between variables can be found, shows that an intimate relation between chemistry and mathematics may be established, although it may be and is the case that the factors have not always been recognized, differentiated, and valuated. Suppose that the problem is to determine the general relation between pressure, volume and temperature of a gas. First, one might keep all other variables (such as gravity, light, magnetic field,

etc.) constant and find how the volume varies with the temperature; then, keeping all other variables constant, find how the volume varies with the pressure. By the aid of mathematics, it is now possible to combine these two relations into a general one which is applicable to all gases after one has inserted into the expression specific constants which depend on the nature of the gas. This equation is

$$(p+\frac{a}{v^2})+(v-b)=RT.$$

where a and b are the specific constants

Many other such mathematical relations have been discovered and have found immediate application. Of course, these are *exact* only in so far as the initial assumptions are exact and the mathematical deduction free from error. The objects and methods of mathematical chemistry are too valuable to be ignored by any one who is desirous of fixing the accuracy of the so-called laws, or of testing theories. It is essential to study the basis underlying these as well as the exact laws discovered experimentally—e. g., combining proportions, definite and multiple proportions, combination by volume, etc.

In its applications, chemistry bears directly on all the other natural sciences. While it is always desirable and necessary to show the inter-relationships, it must be observed that these sciences have not contributed so much to put chemistry on the more rational and scientific basis as have physics and mathematics. The prospects for the future in these sciences cannot be gauged by the results of the past, since new plans and methods are continually being developed here also. If it were possible, every teacher should be trained and interested in the progress of all these related sciences; but, failing that, he should attempt at least to obtain a knowledge as to their aims, methods, results, and possibilities. The progress made in the past by a study of borderland subjects is but an earnest of what the future will repay its students.

But in what particular way will all this scientific training make the chemist better fitted for his work? He will understand more clearly the basis underlying chemistry, where is to be found exact-

ness or inexactness, which theories are sound and which based on insufficient evidence. He will recognize that all stages are not of equal rank in the teaching of chemistry and that at times one single fact may be of such fundamental importance as to outweigh hosts of other facts. He will learn how to perform experiments scientifically, recognizing their aim, devising the method, and explaining the results. Finally, he will have recognized that the methods of chemistry are, or ought to be, the methods of an exact science and that with proper training therein a man may attain the highest type of a scientific education.

The actual problems of the laboratory are many. The teacher must be artist and artisan—a rare combination. There are too many of the artisan class, those who try to raise all their structures on the one model set before them, whether it be their own or that of some educational institution. Such do not necessarily become the trainers of thinking students. The latter have not interrogation points at the end of many of their remarks to the teacher. Any leader of men, whether behind the desk or the writing table, who fails to leave any stray ends for his hearers to think about is, in a most important part of his work, a failure.

How can success be measured? It cannot be done. After recitation or lecture, none feels like congratulating himself—the number of mistakes or errors is too apparent. Illustrative experiments, more careful methods of presentation, more salient methods of attack present themselves continually. The chemist who studies variations must not forget that presentation is one of the least controllable of variables—the one, in fact, over which he can never get complete control and which therefore should call out all his best energies.

If this summary of the overlooked requisites in a chemical training arouses the interest of any so that he examines the subject in greater detail, the writer will feel well repaid.

# THE PLACE OF PHYSIOGRAPHY IN THE HIGH-SCHOOL COURSE.

By Edw. G. Howe.

*Principal of the Preparatory School, University of Illinois.*

There is no more profitable query for a teacher, than, in all honesty, to ask, "What is the desirable end of progress?"

Given, a group of children, with certain attainments and environment, what is the ideal for *them*?.

This question is worthy of the most careful consideration.

Once clearly discerned (even though in an imperfect manner), and the whole future of school or class will be benefited through distinctness of aim and problems of overcoming existing limitations in material equipment and teaching force will be greatly simplified.

This "progress," to be real, must rest upon a proper sequence of subjects.

Curiosity and the aesthetic sense have begun the child's training long before he enters the school room.

Birds, flowers, pebbles, the sunsets, the moon, leaves and the bright fruits of autumn are among the things which have held his interest, led to much unconscious experimentation and opened up many queries.

Even the child of the city has the parks, markets and shop-windows to interest him; and, in both cases, substantial progress has been made.

"The desirable end" would plainly seem to be the fostering and extending of these interests. To put new tools and methods in his hands, as they become strong enough to use them, and extend his horizon until it includes not only what is, but what has been; the *whole* as well as the parts.

In such comprehensive view, not only will the separate details be recognized, but the all-important knowledge of *their relations to each other* will be added.

Now, the fact is, that less and less has this relation of one thing to another been given due regard.

Knowledge has extended to such a degree that specialization

is becoming a serious peril; the results, in many cases, approaching that of astronomy with the law of gravitation left out.

We are so ardent and earnest in pursuit of the one subject in hand as to be in danger of forgetting that, by no possibility, can we know all about one thing until we have viewed it from all sides and in all its relationships.

That a reaction has already set in against this specializing tendency is witnessed by such signs as the growing use of the word "ecology," the character of the laboratory work outlined in texts and the revival of interest in physical geography (or physiography, as the new name is).

One remedy for this lack of correlation might well be to choose some central subjects ("Man," Pope would say), and *master* it; following out its relationships so thoroughly in all their ramifications as to know much of many things while learning all about one.

How feasible such a plan would be is known to the teacher who has given an enthusiastic class the rein and aided them in their study of side issues.

Few of us, however, are so situated as to follow such a plan to its conclusion, and, for the present at least, we must (confining ourselves now to the sciences) take our physiography, botany, zoölogy, chemistry and physics as separate subjects; each of which would greatly profit by coming after the others and having the advantage of their illumination.

As this cannot be, is there no other way by which these subjects can be more completely correlated and the inspiration gained from a broad and comprehensive view of each as parts of a mighty whole?

Before answering this question, it will be well to consider what has been *omitted* in these five common subjects of our high schools; or, if not wholly omitted, still so briefly touched upon as to need more attention.

Briefly enumerated, these are, the atmosphere and its movements, the ocean and its currents, the distribution of heat and moisture, minerals, rocks, soils, land formation and sculpture, the controlling factors in plant and animal distribution and the relation of all of these to man.

Note in passing that this list includes almost the *entire* inorganic basis for biologic life and activity!

Most of these are topics beyond the successful grasp of children in the grades, and for their apprehension require some knowledge of several of the sciences.

Now, in answer, geology will at once suggest itself as competent to supply this lack; but consideration will show its failure in several important essentials, among which are the subordination of the biological element and almost total absence of the human.

Repeated experience in the past has, however, shown that physiography is well suited for this.

In practice, the various sciences were given about the usual degree of attention; each one being vigorously pushed to a tentative conclusion; and then, to supply omissions, revive and freshen past acquirements and at the same time gain a fresh and inspiring new view of the whole, books like Guyot or Maury were made the basis of broad and thoughtful study.

The results were such as to commend the plan to anyone feeling a similar need.

---

## MOISSAN'S WORK WITH THE ELECTRIC FURNACE.

BY FELIX LENGFELD.

The young student who goes into a chemical library and sees the hundreds of volumes that contain accounts of experiments performed by thousands of chemists living and dead, is apt to feel that nothing more can be done along simple lines, that future work must be upon very complex substances or very rare elements. That same feeling existed a hundred years ago and probably the chemist of the twenty-first century will envy us our virgin field.

In 1800, Crell, translating an article of Proust on copper salts, takes occasion to point out that young chemists should take courage when they see what Proust has done with an old subject, and it behooves every chemist to study carefully Moissan's work to

see the prizes that await the careful experimenter. When Moissan had isolated fluorine, after it had eluded other chemists for a century, it seemed to him that the well-known crystallizing power of fluorides might be used to crystallize carbon as diamond. Experiments in that direction failed. Moissan thereupon studied the occurrence of the diamond in nature and concluded that it was formed by the crystallization of carbon under pressure. This could be brought about in the laboratory by dissolving carbon in molten iron and cooling the outside rapidly. Cast iron expands in solidifying and therefore if a crust is once formed and does not crack, the pressure must increase as we approach the center. Carbon is more soluble in hot than in cold iron, and therefore the greater the difference between the melting point of the iron and the temperature at which it is saturated with carbon, the greater the quantity of carbon that separates in solidifying, and the greater the probability of obtaining diamonds. Something hotter than the oxyhydrogen flame was required, and the electric furnace was invented. Its simplicity challenges our admiration. Two blocks of lime or limestone are hollowed out so that a crucible can be placed in one cavity, the other being arched so as to reflect the heat downward. Openings are cut lengthwise to admit the carbons of the arc and the furnace is complete. In some, openings are cut horizontally at right angles to the arc carbons, so that carbon tubes may be inserted and reactions tried protecting the substance from the vapors in the arc. The blocks vary in size, depending upon the current used. In the smallest the lower block is 10 cm. by 18 cm. by 15 cm., in the largest 20 cm. by 35 cm. by 30 cm., the first figure giving the height. The covers are from 8 cm. to 15 cm. high. The carbons vary from 1 to 5 cm. in diameter and the crucibles from 4 cm. in height by 3 cm. in diameter (exterior) to 10 cm. by 9 cm. The crucibles are of graphite, but as this reduces lime they are always separated from the block by magnesia. A single experiment rarely lasts over ten minutes. With large currents the lime melts and even boils, and if the experiment be prolonged there is danger that the molten lime will cement the cover to the lower block. The substances to be heated are placed below the arc and the characteristic of the furnace is

that the arc is used merely as a source of heat and that there is no electric action upon the chemicals. The temperature of the furnace has been estimated at about 3500° and there is little doubt that the boiling point of carbon has been reached, so that it is not likely that higher temperatures will be obtained with larger currents unless means be found for working under pressure. Currents of 50 volts and 35 to 1000 amperes are used. Currents of over 1000 amperes are rarely used, as the disadvantages more than counterbalance the gain. The ordinary precautions in handling large currents and intense lights must be taken, dark glasses, for instance, being absolutely essential. As the electrodes do not fit into the furnace tightly, much heat escapes through the space between carbon and lime, but, on the other hand, the outside of the furnace remains cold and one may place the bare arm on the top of the furnace though the temperature but a few inches off is almost double that of the oxyhydrogen flame, and chalk, silica, manganese boil like water in a kettle.

A mixture of sugar charcoal and iron is heated in the electric furnace and then plunged into water. There is very energetic action, great quantities of oxygen and hydrogen being formed by the dissociation of the water, but there is no explosion. When the mass is cold the iron is dissolved in boiling hydrochloric acid. The residue consists of three varieties of carbon, and other impurities. It is treated with aqua regia, then with boiling sulphuric acid and hydrofluoric acid, then put into sulphuric acid at 200° and potassium nitrate slowly added. The amorphous carbon and most of the impurities are thus destroyed. The graphite is oxidized by the mixture of nitric acid and potassium chlorate. The small residue is again treated with boiling hydrofluoric acid, then with sulphuric acid, washed and dried, and then consists of small diamonds, some black and some transparent. The latter are denser and may be separated from the others by throwing all into bromoform, collecting those that sink and repeating with methylene iodide. The diamonds thus formed resemble most of the varieties of natural diamonds. Like natural diamonds they differ in hardness, color and luster. Though small, the largest being less than a millimeter in length, they are true diamonds. The scientific

problem is solved, but it will probably be many years before large artificial diamonds compete with the natural gem.

The reproduction of the diamond is but a small part of the work done with the electric furnace. At 3500°, carbon reduces most metallic oxides and it is thus possible to make in a few minutes masses of chromium, molybdenum, uranium, ziconium, titanium, etc. Metals that could be obtained only in small quantity and in fine powder with great labor can be made in masses of almost any size and their properties studied. At these high temperatures many metals combine with carbon, forming the interesting substances known as carbides. Some of these, as the carbides of calcium, barium, lithium, give, with water, acetylene; others like aluminium and beryllium carbides give methane; still others give mixtures of gaseous, or even of gaseous, liquid and solid hydrocarbons, and point to the inorganic origin of some petroleums. The carbide of silicon is so hard that it is used instead of emery under the name carborundum. Not alone carbides but silicides, borides, nitrides may be easily formed and many of them have been studied. Many minerals have been reproduced, many more will be, and we can feel certain that the electric furnace reserves many surprises for us, for the chemistry of high temperatures is still in its infancy.

---

## THE STUDY OF BACTERIA IN THE PUBLIC SCHOOLS.

BY JAMES E. PEABODY.
*Instructor in Biology, Peter Cooper High School, New York.*

(*Concluded from page 306.*)

The practical applications of the subject were brought out in discussion of a list of questions from which the following are selected:

1. From all your experiments state—
    - *a.* What conditions seem to favor the growth of bacteria?
    - *b.* What conditions seem to hinder the growth of bacteria?

2. Why are fruits cooked before canning?
3. Why should fruit jars be filled completely before screwing on the cover?
4. Why is grass dried before putting it in the barn?
5. Why are milk, meat, etc., put in the refrigerator in summer time?
6. Why should the prohibition against spitting in public places be rigidly enforced?
7. Why should sweeping be done as far as possible without raising a dust?
8. Why are hard wood floors more healthful than carpets?
9. Why should the teeth be brushed often?
10. Why should the refuse be removed from the streets every morning early, especially in summer time?
11. Why should sink drains be carefully inspected?
12. Why should wounds be carefully cleansed and dressed at once?
13. Why are typhoid fever, diphtheria, and other infectious diseases often best treated in hospitals?

The tables of the New York Board of Health give figures and charts which serve to clinch the arguments in favor of good city housekeeping. The pupils copied into their note-books the following figures giving the annual death-rate per thousand of the population in New York City, 1886 to 1896 inclusive:

| | |
|---|---|
| 1886, 25.99 | 1891, 26.31 |
| 1887, 26.32 | 1892, 25.95 |
| 1888, 26.39 | 1893, 25.30 |
| 1889, 25.32 | 1894, 22.76 |
| 1890, 24.87 | 1895, 23.11 |

1896, 21.52 (first part of year).

There was little need to suggest that the sudden decrease in death-rate in 1894 and in succeeding years was doubtless due in no small measure to the efficiency of the Street Cleaning Department organized and directed by the late Colonel Waring.

After reading Dr. Prudden's books, and after class-room discussions, each pupil was asked to outline at home the arguments in favor of and against the bacteria. The case is stated thus in one of the papers:

*Benefits of Bacteria to Mankind.* They construct food-stuffs for plants out of the nitrogen gas and the solutions absorbed from the soil.

They ripen the cream before churning and thus form butter.

They give flavor to butter.

They are an absolute necessity in making cheese.

In making vinegar from cider, yeast and bacteria work together.

Bacteria perform a very necessary work in the process of "retting" flax in the linen industry, without which we would not have our fine linen and delicate laces.

Bacteria play a prominent part in the curing of tobacco.

Sprouting of seeds is promoted by bacteria.

Streams and lakes are cleared by bacteria.

They decompose dead animals into the dust from whence they came.

*The Ways Bacteria Prove to be "Man's Invisible Foes."* Bacteria cause the diseases, consumption, typhoid fever, scarlet fever, pneumonia, leprosy, lockjaw, influenza, cholera.

They cause blood poisoning.

They destroy foods.

The primary aim of these eight lessons in bacteriology, as already stated, was a practical one, namely, to present to the boys and girls of our city a most telling argument for cleanliness in the care of the home and in the care of the city. The colored charts portraying the cases of consumption in the region of Mott street and of diphtheria in the Tenth and Twelfth wards will not soon be forgotten. Hence the New York of tomorrow will doubtless number among its citizens at least a few more staunch supporters of an efficient Board of Health; a few more homes will probably be free from the danger of disease contagion, and a few more house-wives will exercise greater care to secure abundance of light and of fresh air in their homes and to select and prepare nutritious foods.

The treatment of the subject, however, was not allowed to leave in the minds of the pupils the lasting impression that we have discovered in bacteria an omnipresent and well-nigh omnipotent enemy. They were led to see that consumption, cholera, typhoid, and all the other diseases charged to these micro-organisms are due to the ignorance or carelessness of man, and that

these diseases can be prevented. On the other hand, they learned that the bacteria are toiling incessantly to clear our earth from the debris of decay, and to prepare the soil and the air for the growth of the higher plants. Thus this study becomes a part of the great study of biology, and in this fact lies the deeper interest of the subject. In the hay infusion all the functions of living nature are in full operation. There one may study assimilation, oxidation, respiration, excretion, the life and death struggle for food, reproduction, and even something akin to sensation; for who of us, after an hour at the microscope, watching the varying movements in this world of micro-organisms, is prepared to deny absolutely all sentient impressions even among bacteria? Biological study of this sort should not only result in more healthy bodies for our pupils and a more healthful community, but it should contribute largely to broaden and deepen the mental life of the student.—*Journal of Applied Microscopy.*

---

## LIVING ORGANISMS IN THE STEREOPTICON.*

By W. Pfeffer.

The stereopticon with microscope attachment is little used for the demonstration of living organisms and vital processes in the class room, although its value is apparent, especially for inexperienced students who do not understand adjusting the microscope. A suggestive paper by Dr. W. Pfeffer, of the University of Leipsic, published in the *Jahrbücher für wissenschaftliche Botanik* (Bd. xxxv. h. 40) describes a series of microscopic and macroscopic demonstrations which he gives in his own lecture room.

Swarming movements are interesting, but on account of the difficulty of focussing and of keeping such rapidly moving bodies in the field, as well as not knowing what to look for, they are

*A condensed translation of Prof. Pfeffer's paper by Edith M. Brace, *Rochester, N. Y.*

not easily observed by young students without more personal supervision than is possible in a large class, but by placing a drop of water containing swarm-cells under the microscope of the stereopticon, they may be shown to a large number of students at once.

*Pandorina morum* is especially suitable for this on account of its large size, and the continuation of its movements for from fifteen minutes to half an hour. Some kinds of chlamidomonas, as well as Englena viridis, may also be used, or swarm-spores of Vaucheria, but they are not so good. *Paramecium aurelia* is another favorable organism that is very easily obtained. It is free-moving and irritable, showing a negative reaction to the rays of the electric lantern, although it is not clear whether this is due to the light or the heat. Galvanotaxis may be shown by passing an electric current through the water. The paramecia swim in all directions until the current is closed, when they immediately crowd around the cathode, while if the current is reversed they will swim across to the new cathode, showing a definite reaction, due to some inherent quality, for dead paramecia do not react in this way. *Pandorina morum* may be used for the same demonstration, but it moves more slowly and reacts in the opposite way, collecting at the anode instead of the cathode. An objective of low power, with large field, is preferable for this demonstration.

Paramecia and other colorless infusoria are shown with great distinctness by the stereopticon, or they may be stained with an .001-.005 per cent. solution of methylen blue, which is collected in masses in the contractile vacuole.

Quantities of paramecia should be available. They may be obtained from stagnant ponds, or from infusions made by leaving hay in water from four to eight days. They are found in greater numbers on the sunny side of the aquarium.

A bit of decaying matter placed on the slide just before the demonstration will attract them and show their tendency to heap themselves up around such material, but if left for a few moments they will all become scattered on account of the repelling action of the acid which they excrete.

*Euglena viridis* is also a good subject, and only after considerable exposure to the light begins to round off and form the resting stage, the observation of which is of still further interest. The streaming of protoplasm is not so easily demonstrated, but the rotation of starch grains may be shown with water-immersion objective 1.7 mm. or oil-immersion 2 mm., with ocular 2* or 4, projecting to a distance of 4 m. When thrown on a screen 80 to 100 cm. distant, they were as clearly shown as by microscopic examination.

Plasmodia of Myxomycetis are irritable to light, but may be shown in the steropticon with a weak current. The moving motion of oscillaria may be very beautifully shown by the stereopticon, but the filaments must be freshly mounted, for the movements gradually become weak after they have been placed upon the slide.

Many processes, such as alcoholic fermentation and intercellular permeability, are easily shown, as well as macroscopic objects. Contractile stamens of *Cynarea jacea* or *C. scolymus* were shown by placing the flower in water and removing the top of it to expose the stamens, which throw out a mass of pollen when touched. The leaves of Oxalis slowly droop if the plant is repeatedly shaken. A small specimen of *Mimosa pudica* may be placed before the stereopticon and all its reactions to stimuli shown. The growth of the root of a seedling may be shown by placing it in a jar of water surrounded by warm water. This requires high magnification to increase the apparent rate of growth.

For these demonstrations, the large projection apparatus of Zeiss was used, and the self-regulating lamp of Schuchert & Co., with electric current of about 30 amperes, as 60-70 amperes can hardly be used, the specimens being killed by the heat with a current of 30-50 amperes, unless special precautions are taken. To guard against this, the light from the electric lantern is passed through a glass cell 200 mm. thick, filled with water, which absorbs heat nearly as well as the saturated solution of alum commonly used.

Dr. Pfeffer also used a cell about 40 mm. thick filled with an

almost saturated solution of iron sulphate. This absorbs some of the visible rays and transmits a greenish light, which, however, is strong enough to project a magnification of 4,000 to 8,000 diameters. The water cell was surrounded with a zinc case in which ice was packed to further cool the apparatus. The translator has used a cell of about 150 mm. thickness, filled with a saturated solution of alum water, which was sufficient for demonstrations lasting not more than forty-five minutes, after which the cell was cooled under the faucet before the next demonstration.

---

## DYNAMIC MEASUREMENT OF FORCE.*

By N. H. Williams.

*Instructor in Physics, Shortridge High School, Indianapolis.*

Although Newton's second law of motion may be axiomatic to the scientific mind, there can be no doubt that its application to the measurement of force is a problem that the student of elementary physics usually finds troublesome. Illustrations which are perfectly clear to some, seem to lie beyond the experience of others and usually fail to appeal to a majority. We often resort to experiment to clear up difficult points, and so it would seem in this case, that if the subject could be illustrated by some simple apparatus, its difficulties might be diminished. The student's ideas are vague and he needs something tangible upon which he can fix his thought.

Newton's second law of motion gives us one proportionality and another is even more obvious:—Momentum varies as Force, *i. e.*, $M V \propto T$; and Momentum varies as Time, *i. e.*, $M V \propto T$. If one quantity varies as two others jointly, it varies as their product, hence $M V \propto F T$ or $F \propto \frac{M V}{T}$ This may be

*Read before the Physics Conference of the Michigan Schoolmasters' Club, March 30, 1901.

written in the form of an equation, $F = \frac{MV}{T}$, provided we choose our units to fit the equation.

We are given our choice among three definitions of a unit of force. *First.* A unit of force is that force which will produce unit change of momentum per unit of time. *Second.* A unit of force is that force which, acting upon unit mass, will produce unit acceleration. *Third.* A unit of force is that force which acting for a unit of time upon a unit mass will produce unit change of velocity.

Suppose we choose the second definition. In order to illustrate this, it is evident that we must have a known mass acted upon by a known force and that we must be able to measure the acceleration. The product of the mass by the acceleration should equal the applied force.

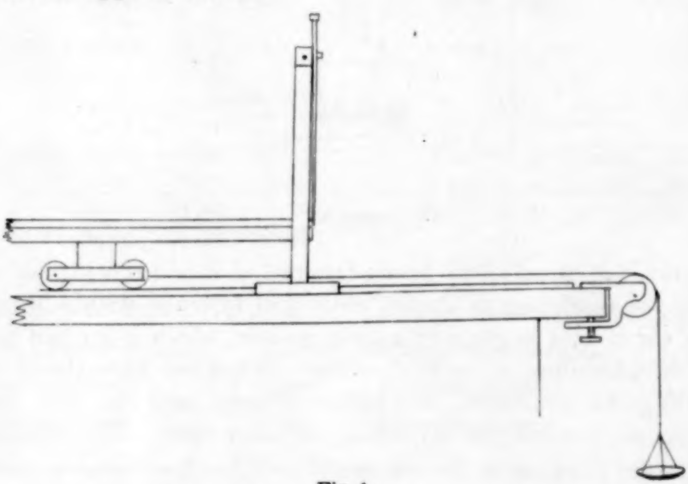


Fig. 1.

The mass consists of a car (Fig. 1) carrying a heavy wooden rod about a meter long. A thread fastened to the car passes over a pulley at the edge of the table and carries a scale-pan at its other end. This pan and the weights in it must be considered as part of the mass moved. The car runs on a long piece of plate glass which lies upon the table. Before the weight is put into the pan the glass is adjusted by slightly raising one end till the

car, when started, will have a uniform motion. Then by Newton's first law no unbalanced force is acting upon it. When the weight is placed in the pan, the car will have uniformly accelerated motion, and it remains for us to measure the acceleration. A pendulum (Fig. 2) vibrating half-seconds is suspended over

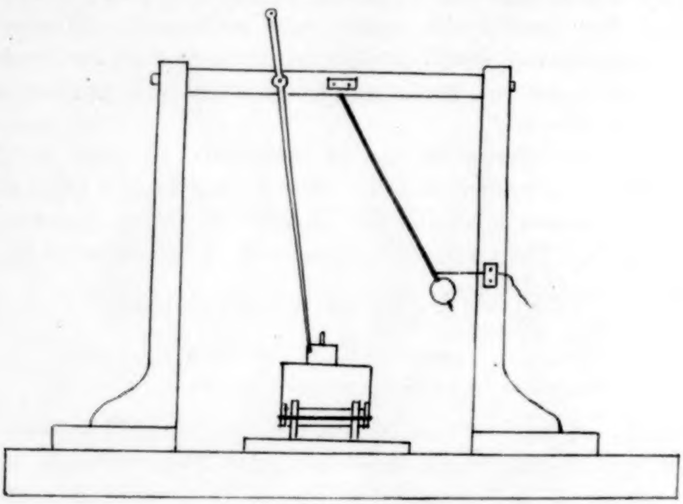


Fig. 2.

the car. A camel's-hair brush fastened to it is wet with ink and then the pendulum is drawn aside and fastened with a thread. The car is held in place by a long pointer, which is thrown aside by the pendulum at its first swing. When we burn the thread holding the pendulum, the car is released and the first mark across the wooden rod is made at the same time. The pendulum continues to swing as the car moves and thus the distances passed over in successive intervals of time are marked. The second, fourth and sixth marks are disregarded and the distances passed over in one, two, three, and four seconds respectively are recorded.

The total distance divided by the time gives the average velocity. Doubling this we get the final velocity, and the acceleration is the quotient of the final velocity by the number of seconds. We find the average acceleration and multiply it into

the mass moved. This result is in dynes. It is then reduced to grams and compared with the weight in the pan causing motion.

This experiment is fitted only for class-room work, as the adjustments are too delicate to permit of its being used as a laboratory experiment. The apparatus should be set up and adjusted before the class period during which it is used. When once adjusted, a few seconds only are required to get the results.

It will be observed that the apparatus will give the laws of accelerated motion, and might take the place of Atwood's machine. It also works admirably in experiments on "The Acceleration Test for Masses."

### SOME RESULTS GIVEN BY THE APPARATUS.

| TOTAL MASS | | | 1166 g. | |
|---|---|---|---|---|
| FORCE APPLIED | | | 10 g | |
| t | S | Av. V. | Final V. | Acceleration |
| 1 | 4.25 | 4.25 | 8.50 | 8.50 |
| 2 | 17.00 | 8.50 | 17.00 | 8.50 |
| 3 | 38.10 | 12.70 | 25.40 | 8.46 |
| 4 | 67.80 | 16.95 | 33.90 | 8.47 |

| | |
|---|---|
| Average acceleration..... | 8.482 |
| Mass × Acceleration ..... | 9890 |
| Force in grams ........... | 10.90 |
| Percentage error ......... | 0.9% |

| TOTAL MASS | | | 1171 g. | |
|---|---|---|---|---|
| FORCE APPLIED | | | 15 g. | |
| t | S | Av. V. | Final V. | Acceleration |
| 1 | 6.34 | 6.34 | 12.68 | 12.68 |
| 2 | 24.90 | 12.45 | 24.90 | 12.95 |
| 3 | 55.70 | 18.90 | 37.80 | 12.60 |

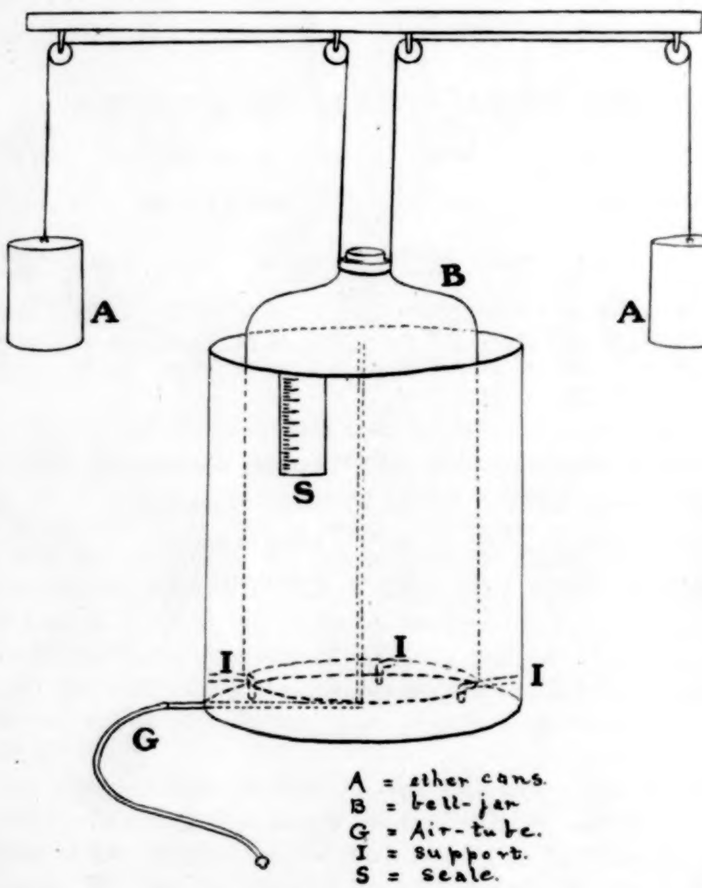
| | |
|---|---|
| Average acceleration..... | 12.58 |
| Mass × Acceleration ..... | 1450 |
| Force in grams........... | 15.03 |
| Percentage error ......... | 0.2% |

## A SPIROMETER AND ITS USE.

GRACE F. ELLIS.

*Instructor in Biology, Central High School, Grand Rapids, Mich.*

The spirometer in question was the result of many experiments and much trouble, but it could be duplicated or imitated without difficulty.



The can in which the bell-jar stands is of zinc 18 in. high and 10 in. in diameter. At the bottom are three supports on which the jar rests. The air tube enters on one side and is continued by rubber and glass tubing to nearly the top of the bell-jar. In this way it is not necessary to turn the stop cock in order to read the result.

At the top of the jar a piece of window glass is fastened with putty. Through this the graduations on the bell-jar can be read.

The jar is not graduated for the first 50 cu. in., as it is not necessary, and I fill the can so that the water is on a level with the first mark on the jar.

Graduations are for five cu. in. and the results are a close record of lung capacity.

At the top of the jar is a rubber stopper; removing this allows the jar to sink into the can after use.

The upward movement of the jar under air pressure is greatly facilitated by counterpoises. These are ether cans filled with red lead and attached to cords fastened at the neck of the jar and running over two pulleys on either side, which, in turn, are attached to a bar. The bar is rested across any two points at a suitable height, and the whole apparatus can be taken down and put away when not in use.

Both can and jar are larger than is absolutely necessary, as the former was made to accommodate a bell-jar also used to cover a compound microscope. Smaller apparatus would be more convenient and answer every requirement as well as this.

In connection with this apparatus the student is given a card calling for certain "vital statistics," which, when ascertained, are recorded in his laboratory note-book of physiology. He must get his exact weight before coming to class; height and chest measurements are taken at the laboratory. I use the following standards for tests of vital condition:

1. *Corpulence.* Relation of weight in pounds to height in feet. For a man 26 is the standard; below 23 he is abnormally thin. For a woman, 23 is the standard; below 21 is abnormally thin. In estimating the exact value of corpulence it should be taken in connection with vital capacity.

2. *Vital Capacity.* Normally, for a man of five ft. eight in., it is 230 cu. in. Relation between height and capacity for a man is 1 to 3, for a woman 1 to 26; *i. e.,* for each inch of height in a man there should be three cu. in. of lung capacity.

3. The thoracic perimeter should never be less than one-half the height of an individual. In man it is normally never less than 35 in.

Below is given a record from a student's notebook:

VITAL STATISTICS.

***Name.*** James B. ***Age.*** 18 yrs. ***Height.*** 71 in. ***Weight.*** 145 lbs.

**CHEST** { ***Inspiration.*** $33\frac{1}{2}$. ***Expiration.*** 31. ***Average.*** $32\frac{1}{4}$. } ***Lung Capacity.*** 265 cu. in.

**Multiply your height in inches by 3 (if a boy), and by 2.6 (if a girl).**
***Result.*** $71 \times 3 = 213$ **cu. in.**

**My average is $3\frac{2}{3}$ cu. in. to each inch of my height.**

***Chest Average*** $= 32\frac{1}{4}$. ***Half Height*** $= 35\frac{1}{2}$.

$$\frac{\textit{Weight in pounds}}{\textit{Height in feet}} = 24\tfrac{36}{71}.$$

It is not necessary to suggest the various uses to which such a record may be put. There is no stronger argument for physical development.

---

# ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

*(Continued from page 319.)*

## EXPERIMENT XI.

*To find rate and period of the moon's diurnal motion.*

(a) Stick a piece of lath, provided with a sight at the end, in the ground, and line in with the moon and this stick a second lath, pushing it into the ground firmly enough to hold it against

the wind. Indicate on the second lath the point where the line to the moon passes it. A half-hour or an hour later line in a third lath and mark it as you did the second. Note and record the time to the nearest minute in each case. Stretch strings from

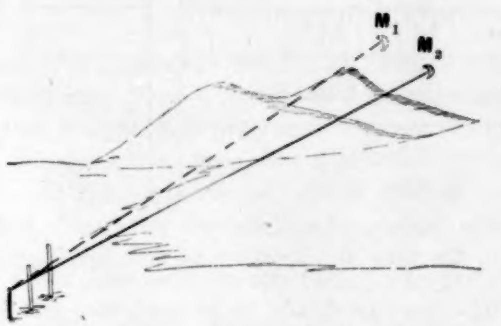



Fig. 14.

the first to both the second and third laths, and transfer the angle between the strings to paper, and measure it, or measure the angle directly. Finally, find how long it will require the moon to pass through 360 degrees at this same rate.

(b) It will be readily seen that this experiment may also be performed with the home-made plane table.

## Experiment XII.

*To measure angles between objects (stars, planets, etc.) in the sky.*

(a) It will be readily seen how this may be done crudely with the aid of the data of Experiment II.

(b) A cross-staff or bar is recommended for this purpose also. This consists of a light stick some three feet long (a meter or yard stick), carrying a nail sight or perforated strip, at one end (the eye end), and provided with another stick which is held at right angles to the first, and sliding easily back and forth along the former. The cross-stick should be supplied with three or

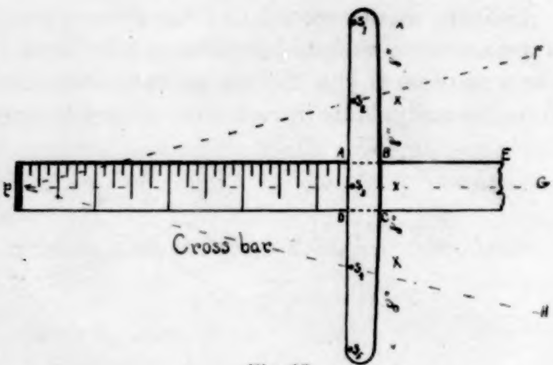



Fig. 15.

five sights, (S1, S2,....S5) one at either end, and a third in the middle. The cross-bar should be at least two feet long. The trigonometry class may graduate the long stick to correspond to various angles, and write the angles S1 p S3 and S2 p S3) beside the graduation marks. The sights must be large enough to be seen in poor light. The method of using this instrument is obvious. A faint light, placed behind the observer's head, will illuminate the sights sufficiently.

(c.) The experiment may also be performed with the sextant. It is a good exercise for the home-made sextant referred to under Experiment VII (d).

### Experiment XIII.

*Locate stars on a spherical blackboard from Ephemeris values of Right Ascension and Declination.*

(The Chicago Laboratory Supply and Scale Co. can furnish inexpensive globes for this purpose.)

(*To be continued.*)

# Metrology.*

## PARTIAL USE OF DECIMAL SYSTEM THIRTY-FIVE YEARS AFTER LEGALIZATION.

[CONTRIBUTED.]

The process of transition to the use of Federal money, inaugurated by resolutions of the Congress of the Confederation, July 6, 1785, and Aug. 8, 1786, was protracted through the time of our grandfathers, the generation following that which established the money. Kelly's *Universal Cambist,* whose preface is dated in 1821, thirty-five years after the original legislation, is a standard authority, having had official support. It said of the United States:

"Accounts are kept here in different ways, but chiefly in Dollars, which are divided into 10 Dimes, 100 Cents, or 1,000 Mills. This is called Federal Money, to distinguish it from the various currencies which were formerly the monies of the United States, and which are still partially retained in domestic traffic," etc.

The constitution of Massachusetts said then, and says now, in Chapter VI:

"III. In all cases where sums of money are mentioned in this constitution, the value thereof shall be computed in silver, at six shillings and eight pence per ounce," etc.

The United States Mint, though it began to coin money in 1793, did not strike many coins except cents, half-cents and half-dollars down to 1820; and coins of the several nations of western Europe continued in circulation. The Spanish original of our dollar was well known as the "piece of eight," meaning eight "bits" in the vernacular tongue of the United States, where the Spanish name is less familiar; one bit thus becomes 12½ cents obviously to us, but our grandfathers knew it as of the value expressed according to their long established custom in their different monetary reckonings. John Quincy Adams, Secretary of State, in his celebrated report on weights and measures, also dated in 1821, wrote as follows:

*Communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

* * * "now, when the recent coinage of dimes is alluded to in our public journals, if their name is mentioned, it is always with an explanatory definition to inform the reader that they are ten-cent pieces; and some of them which have found their way over the mountains, by the generous hospitality of the country, have been received for more than they were worth, and have passed for an eighth, instead of a tenth, part of a dollar. Even now, at the end of thirty years, ask a tradesman or shopkeeper, in any of our cities what is a dime or a mille, and the chances are four in five that he will not understand your question. But go to New York and offer in payment the Spanish coin, the unit of the Spanish piece of eight, and the shop or marketman will take it for a shilling. Carry it to Boston or Richmond, and you shall be told it is not a shilling but nine pence. Bring it to Philadelphia, Baltimore, or the city of Washington, and you shall find it recognized for an eleven-penny bit; and if you ask how that can be, you shall learn that, the dollar being of ninety pence, the eighth part of it is nearer to eleven than to any other number," etc.

This was characterized by Mr. Adams as absurd, and justly. Oh, yes—but—by the way, what is it that we are doing, A. D. 1901, thirty-five years after the inauguration by our fathers by the Act of Congress of July 28, 1866, of the change to metric weights and measures? Our rates of postage on foreign mail matter are by weights in grams, and we try to look them up in pocket diaries or other common places of reference and find them inaccurately stated by weights in ounces. We turn to the Revised Statutes of the United States, Section 3515, referring to our minor coins, and read:

"The weight of the piece of five cents shall be seventy-seven and sixteen-hundredths grain troy":

a circumlocution for five grams. We have had profile paper printed with metric subdivisions for its whole length and have measured it off in portions for sale by the yard. Imported paper in rolls of ten meters we have advertised as eleven-yard rolls. These few examples suffice out of many instances of misapplication of units of quantity in business and in publications.

We see the unreasonableness both of the Massachusetts constitution and of the adherence by our grandfathers, so long after they had established decimal reckoning, to their antiquated bookkeeping, which occasioned great inconvenience from the incongruity of the two methods in use at the same time. When our grandchildren look back to 1901, what will they say of our now

hanging on to weights and measures that are out of date by consequence of the substitution of the metric units legalized thirty-five years ago?

Consider electricity, whose standards of measurement are fixed upon a metric basis by the law of July 12, 1894. The following is an extract from it:

> "The unit of power shall be the watt, which is equal to ten million units of power of the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one joule per second."

Several of the electrical units have become familiar to us through the enormously rapid development of the applications of electricity. This is the case especially with the kilowatt, a commercial unit which we meet with in almost every technical publication we take up; but it has not yet entirely displaced that anomalous old unit, the horse-power (as to which reference may be made to *Engineering*, vol. 63, pp. 245 and 325, for Feb. 19 and March 5, 1897).

Consider the matter of assaying and coinage, in which the metric system is established. It has been used in the Mint for years, and is used in published tables or schedules of coins. The United States subsidiary silver money weighs one gram per four cents, and thus metric weight is in everybody's pocket. The troy pound has dropped out of practical use. Nevertheless, the troy ounce, incongruous as it is with other weights and measures, still comes in our way sometimes (in other places besides the Massachusetts constitution).

Consider pharmacy and some other matters connected with chemistry. The *United States Pharmacopoeia*, the reference manual of the apothecary, is exclusively metric. The *Dispensatory*, the corresponding manual of the physician, has metric values throughout. The use of the metric system was introduced in the United States Marine Hospital service about a quarter of a century ago quite thoroughly, and in the army and navy more recently. In practice in civil life prescriptions are to a large and increasing extent written in metric terms; but the mysterious old "apothecaries'" weights and measures (which for sales of candy and popular wares are not used by apothecaries) continue to be

used in the prescriptions of some of the older physicians, who in the natural course of events are gradually passing off the stage. Meanwhile pharmacists have double sets of weights and measures, and employ clerks who understand both, with extra trouble, cost and risk of mistake. In the sale of high grade chemicals the metric system has been introduced. E. R. Squibb & Sons, of Brooklyn, have used it exclusively for nine years, and the Bausch & Lomb Optical Co., of Rochester, issues a sixty-page priced catalogue "G" of "Chemicals and Reagents" in metric terms, with a conspicuous notice at the top of each page, "Prices of Chemicals are by Metric, NOT Avoirdupois Weight." Much glassware and rubber stoppers are made to metric scale. As to chemical manufacturing, all the tanks in a factory built by the Merrimac Chemical Company, of Massachusetts, for their extensive sulphuric acid works, were made on metric dimensions, and the Pennsylvania Salt Manufacturing Company have built a large plant entirely upon metric dimensions. The great Solvay Process Company, of Syracuse, makes use of the metric system in every way possible in its works. Drawings to go outside of the works for construction, etc., are not made in the metric system. The company says it finds no disadvantages, and would be very glad if its entire work could be upon the metric system. That means that as long as people outside cling to ancient weights and measures, so that conformity with them is required of the Solvay Process Company, the company gets only part of the advantages naturally belonging to its system. Chemical analyses are expressed in parts per million, per hundred thousand or per thousand, corresponding to grams per cubic meter, per hektoliter or per liter. Grains per gallon are out of date. Nevertheless, in dealing with quantities and consumption of water there still lingers some use of the United States liquid gallon, a unit long ago abandoned in Great Britain and Canada, distinguished for its lack of connection with other measures or weights, and not ordinarily used in the reading of water meters.

Consider geodesy and precise leveling. The metric measure has been very extensively used in precise leveling or other work of the United States Coast and Geodetic Survey, the United States Geological Survey, the United States Lake Survey, and the sur-

veys under the Mississippi River Commission. Among other literature from which evidence may be obtained about this, and about working in old measures incongruous with metric, there is an article and discussion on "Precise Spirit Leveling," occupying pp. 1-206 of Vol. 45 of the Transactions of the American Society of Civil Engineers, June, 1901.

Bulletin No. 26 of the United States Coast and Geodetic Survey, dated April 5, 1893, contained an announcement signed by T. C. Mendenhall, Superintendent of Standard Weights and Measures, and approved by John G. Carlisle, Secretary of the Treasury, from which the following is an extract:

> * * * "the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the international prototype meter and kilogram as fundamental standards, and the customary units, the yard and the pound, will be derived therefrom in accordance with the Act of July 28, 1866. Indeed, this course has been practically forced upon this Office for several years," etc.

The Treasury Department is the department to which are attached the Mint, the Marine Hospital Service and the Coast and Geodetic Survey, in all three of which, as above stated, the metric system has been in practical use for years. Incongruity is found, however, in the fact that the Treasury Department continues the use of old weights and measures in other branches of its work; for example, in its Bureau of Statistics, largely occupied with foreign trade (whereas metric units have been introduced to some extent in the Bureau of Foreign Commerce of the State Department and in the section of Foreign Markets of the Agricultural Department); and, for another example, in the Customs Service, where there will be special gain in the substitution of the international system, and where its substitution has been repeatedly urged, officially and unofficially.

Consider manufactures. The April, 1900, report of the American Railway Association's Committee on the Metric System enumerated among manufactures in which the metric system has been introduced watches, injectors, refrigerating apparatus, screw-cutting lathes, scales, drills, gauges, astronomical and physical instruments, measuring implements and draughtsman's supplies. A very large number of manufacturers have had some call for the application of metric measurement for goods for

export, if only on a small order; and goods of widely diverse character are among the metric manufactures. We have exported to metric countries a great deal of ordnance and machinery for manufacturing ordnance, and rapid-firing guns have been designated by their caliber in millimeters. The Baldwin Locomotive Works' illustrated catalogue of narrow-gauge locomotives has printed on its title page, "Adapted Especially to Gauges of 3 Feet 6 Inches or One Metre," and on each of the sixteen pages (108-38), on which are tabulated various types of locomotives, has printed conspicuously, "Gauge, 3 Feet 6 Inches, or One Metre." The Library Bureau, of Boston, has cards and cases made of exact metric dimensions. In the *Electrical Review* (New York) for June 22, 1901, Geo. H. Draper says:

"There is no first-class shop in America that will not undertake to build machinery according to metric measurements, and many of them are at the present time compelled to build stock forms of machinery in measurements of this system in order to be able to compete for trade in foreign countries where the specifications are given in round metric terms."

---

## NOTES.

*A Decimal Association.* At the August meeting of the American Association for the Advancement of Science, held in Denver, Colo., Jesse Pawling, Jr., of the Central High School, Philadelphia, read an instructive paper on the metric system, advocating the formation of a Decimal Association, similar to the one in England, for the purpose of promoting metric reform and urging the passage of a metric bill by Congress.

*The Metric System and International Commerce.* Under this title Cassier's for September contains an interesting paper by J. H. Gore, secretary of the American Metrological Society. The one great question now paramount in the minds of the commercial world, he says, is how to extend trade—how to remove the barriers that stand in the way of natural tendencies and artificial stimuli. He quotes Mr. Furbish, formerly director of the Bureau of American Republics, who says: "The failure of the United States Government to adopt the metric system is one of the most inexplicable instances of false conservatism in the history of the country. We send consular representatives to every quarter of our globe for the express purpose of making possible an extension of our foreign commerce, and then busy ourselves in an attempt to make such foreign commerce impossible, and retain a system of weights and measures which adds to our own difficulties and makes us mere barbarians to the more

progressive nations." He mentions that letters from eighteen important consulates to the British House of Commons, in every case state that the adoption of the metric system by Great Britain would greatly promote her commerce. "There can be no possible doubt of these facts, and the United States, in its commerce, is today suffering from the same cause. We are out of touch commercially with all the nations of the world except Russia, with which our commerce is small, and England, with which our trade is not growing."

*Evolution of Standards of Measurement.* In the September *Cassier,* John A. Brashear writes of the development of linear standards and machines for making exact divisions. The early standard in Biblical writings and in Egypt, Babylonia, Persia, Greece and all eastern countries was the cubit. Medieval metrology is omitted for "a period of more than a thousand years over which the connection of units of measure is very uncertain." The Belgic foot was probably carried over to Great Britain in the tenth century, and was 13.22 of our present inches. The legal foot of 12 inches was enforced by law in 950, at which time Henry I. made it one-third of a yard, the later standard being half the distance from the finger tips of that king's outstretched arms.

In 1324 Edward II. created a new standard—the barley corn, 3 grains of which placed end to end were decreed to make an inch. From this time onward for 500 years the yard and ell had various values, until 1824, when George IV. gave a legal definition to the yard as marked on a certain bar made by Bird in 1760. This was known as the Imperial Standard Yard, and has ever since remained the standard of length in England.

The rise of the metric system is briefly described. Down to the beginning of the seventeenth century there were no instrument makers, but about the middle of that century astronomy demanded a higher grade of instruments. Whereas the earlier *circles* were all divided by hand. dividing engines are now employed with much greater precision, as in setting off *linear* measurements. Space is given to the names and work of inventors and users of these engines. Reference is made to the work of Michelson with the refractometer in measuring the length of light waves, which furnished a delicate subdivision of the meter.

The paper ends with a brief account of the invention since about 1860 of machines for making interchangeable parts and standard screw threads, in which latter, the author says, there has been a saving to the railways of the United States of hundreds of thousands if not millions of dollars. The fineness of such measurements is shown by the possibility of making all standard gauges accurate to within one-forty- or fifty-thousandth of an inch; while gratings by Rowland's engine can be made 120,000 to the inch so accurate that an error of one two-millionths of an inch is not found between adjacent lines. Such lines open great possibilities in spectrum analysis.

R. P. W.

# Notes.

**Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of great value.**

## CHEMICAL.

*Aluminum Iodide* may be very readily prepared by putting a mixture of equivalent proportions of aluminum foil and iodine with about three times its weight of carbon bisulphide in a glass stoppered vessel. The mixture is allowed to stand at the ordinary temperature. The iodide dissolves in the carbon bisulphide as soon as it forms, and in a couple of days the reaction is completed.

Jour. Prak. Chem. (2), LXIII, 110. G. GUSTAVSON.

*Temperature of Ignition of Phosphorus.*—A current of air or other gas was bubbled through melted phosphorus under water. The temperature was gradually raised and readings on a thermometer in the water taken at regular intervals. The ignition point was taken to be the temperature at which the temperature of the water began to rise rapidly. This was found to be 45.0 to 45.2 deg. in air or ogygen, or air mixed with an equal volume of carbon dioxide.

Rec. Trav. Chim. XIX, 401. F. H. EYDMANN.

*Preparation of Anhydrous Calcium Chloride.* Calcium chloride is a good drying agent only when it is quite free from water. Small quantities of the chloride may be rapidly and perfectly dried as follows: A lump of the chloride is grasped with tongs and held in a large blast lamp flame. It soon begins to melt and drops fall off. These may be caught on a sheet of metal placed under the lamp, and the flattened, solidified drops put in a tightly corked bottle without delay. Calcium chloride so prepared makes a very efficient drying agent, as it is perfectly anhydrous and presents a good deal of surface for its mass.

*The Metallic Luster of Sodium or Potassium* is hard to show to a class, as these metals oxidize so readily. By the following method, however, the metals can be obtained under conditions permitting of the preserving of their metallic luster indefinitely and of ready demonstration. A test tube is filled half full with paraffine which is melted in a bare flame, and heated until it is hot enough to begin to smoke. Pieces of sodium or potassium as large and as clean as possible are dropped into the hot paraffine. They are then well shaken in order to remove the coating of oxide and the tube laid in an almost horizontal position to cool. Oftentimes the metals form into balls which cannot be made to coalesce, but these flatten along the glass and exhibit the metallic luster as well as a continuous band of the metal.

*Electrolytic Manufacture of Sodium.*—In Fischer's process a mixture of 75 parts of potassium chloride and 59 parts of sodium chloride is electrolyzed in an electric furnace in a wide and shallow crucible provided with a middle partition not quite reaching the bottom. The horizontal electrodes pierce the sides of the crucible at opposite ends of a diameter perpendicular to the partition. The anode is a solid carbon rod, and the cathode a metallic tube, whose axis is level with the surface of the fused mixture in the crucible. The sodium formed contains only about one per cent of potassium and is removed through this tubular cathode. The advantage of using two chlorides is that their mixture has a lower melting point than either of the chlorides alone, and the temperature can therefore be kept down, thereby preventing much loss of sodium by volatilization.—*Electrochemist and Metallurgist.*

*Preparation of Ethylene.*—"About 50 or 60 cc. of syrupy phosphoric acid of sp. gr. 1.75 are placed in a small Wurtz flask of about 180 cc. capacity. The flask is fitted with a cork carrying a thermometer and a dropping tube, the end of the latter being drawn out to a fine tube, and reaching to the bottom of the flask. Phosphoric acid of sp. gr. 1.75 boils at a temperature of about 160 deg. It is heated in the flask and allowed to boil for a few minutes until its temperature reaches 200 deg., when ethyl alcohol is allowed to enter drop by drop. Ethylene is immediately disengaged, and by maintaining the temperature between 200 and 220 deg. a continuous supply of the gas can be obtained even from so small an apparatus at the rate of 10 to 15 liters per hour. The gas should be conducted through a small Woulf's bottle (100 to 150 cc. capacity) standing in a vessel of ice, in which an aqueous liquid collects containing a small quantity of ether, undecomposed alcohol, and traces of an oily liquid. The gas which passes on is practically pure ethylene, and contains no trace of carbon dioxide, and of course not sulphur dioxide. It is absorbed completely by fuming sulphuric acid. There is no charring or separation of carbon in the reaction flask, for although the liquid assumes a brownish color, it remains perfectly clear. The mixture does not evince any tendency to 'froth up,' hence the operation may be carried out in small vessels. The process appears to be continuous, and so long as the supply of alcohol is maintained, the operation will go on without attention for apparently an indefinite period. In one experiment the action was allowed to continue for several hours a day for a whole week, during which time several hundred liters of ethylene had been generated by the same quantity, 50 cc., of phosphoric acid."

Jour. Chem. Soc., LXXIX, No. 916. G. S. NEWTH.

## PHYSICAL.

*The Largest Induction Motor* in the world has a capacity of 1,000 horse power at 5,000 volts. It was made in Switzerland.

*Ions in the Atmosphere.* H. Ebert has found that the number of ions in the atmosphere is very much larger in clear, sunny weather than in air filled with dust or moisture, although the number is very small in either case. The free charges in one cubic meter amount to about one electrostatic unit, an amount that would be accounted for by the dissociation of the 10,000 billionth part of the oxygen. This amount of ionization is about the 100,000th part of that produced by feeble Roentgen rays.

*Aluminum for Kundt's Experiment.* Aluminum rods three-eighths to a half inch in diameter are superior to the brass rods commonly used in the determination of the velocity of sound by Kundt's method. The tone is not only more resonant but it is also more uniform and more easily started, there being none of the slipping of the rubbing cloth too often observed with brass. The tone is remarkably clear and musical and the comparative absence of overtones causes the nodes to be particularly well marked in the tube.

*"What is Electricity?"* was once asked of Thomas A. Edison. His reply was: "I don't know, for I am not an electrician. I am a mechanic who happens to know that under certain conditions and with certain guiding appliances the electric current will do certain things. I simply utilize the work of electricity just as an engineer will utilize the work-giving properties of live steam. He doesn't know exactly what steam is. He knows that if water is heated in a closed boiler and is made hot enough that what he calls steam operates his engine. If you tell him it is not the steam, but heat, that does the work, he cannot successfully prove that you are wrong. As a matter of fact, it is heat in the steam which gives steam its expansive properties. The steam, the vaporized water, is simply the vehicle which carries the heat to the point where the work is accomplished. Now, that is the way I look at electricity. The current, if it is a current, is a movement of something which I know will give me certain results under certain conditions. All I have to do is to meet the requirements and I will surely accomplish my planned results."

*A New Storage Battery* has recently been patented by Thomas A. Edison. Magnesium is used as the support upon which the zinc is deposited when the battery is reversed after discharging. Although mag-

nesium has a greater solution tension than zinc, there seems to be no local action between the metals. The zinc adheres very firmly to the magnesium even when the current density is quite considerable. The negative element consists of finely divided copper which is first moulded into form, then converted by heating into the black oxide, and finally reduced. In charging the copper is converted into the red oxide. The copper is supported in perforated receptacles attached to nickel or nickel-plated plates. The solution is a twenty per cent solution of sodium hydroxide in which zinc hydroxide is dissolved nearly to saturation. The charging is continued until about seventy-five per cent of the zinc in the solution is deposited on the magnesium. The battery has a voltage of 0.67 volt.

---

## Reports of Meetings.

### EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The thirty-first meeting of the Association was held in Salem, Mass., Saturday, November 16, 1901. The members of the Association were the guests of Mr. Charles E. Adams, teacher of Physics in the Salem Normal School. About twenty-five members were present. President Herbert J. Chase of the Danvers (Mass.) High School presided. After the customary routine business the following new members were elected: Mr. Arthur N. Burke, High School, Waltham, Mass.; Mr. Kirk W. Thompson, High School, Beverly, Mass.; Mr. Walter H. Buck, High School, Leominster, Mass.

In the absence of Mr. C. H. Andrews, chairman of the committee on apparatus, Mr. I. O. Palmer presented the following report: Attention is called to three pieces of apparatus. (1) A D'Arsonval Galvanometer. This galvanometer is compact and handsome. Like all galvanometers of this class it is independent of external magnetic fields and is nearly dead beat. The sensibility is about seventy-five megohms. As it is a mirror galvanometer, either a reading telescope or a sight and scale attachment is necessary. The price, including the sight and scale attachment, is about $14.50. For very accurate work it is recommended that a reading telescope be substituted for the sight and scale attachment. This galvanometer is serviceable when it is desired to put a high grade instrument into the hands of an ordinary pupil. (2) A Jolly Balance. This balance consists of two nickel plated telescoping tubes, mounted on

an iron tripod, with leveling screws. The inner tube can be adjusted up or down by a milled knob, and 50 cms. of its length is graduated in millimeters. A portion of the end of the outer tube is cut away and the edge is beveled. On this edge is cut a scale 9 mm. long, divided into 10 equal parts, thus forming a vernier which permits accurate reading to tenths of a millimeter and approximate ones to hundredths of a millimeter. The spiral spring is suspended from the crossarm of the inner tube. On the lower end of this spring is fastened an indicator, consisting of a narrow strip of aluminum having two crossarms, one above and the other below a glass tube through which the indicator passes. This arrangement permits a play of only 12 mm. of the spring up or down when objects are placed on or removed from the pans. In using this balance the indicator is first brought to zero by adjusting the tube which carries the spring and then reading the vernier. Any elongation of the spring is measured by raising the inner tube until the indicator is again at zero, and then reading the vernier The difference between the two readings measures the elongation. This balance is very accurate.* (3) An Attachment for a Second's Pendulum. This attachment is intended to replace the customary mercury contact for indicating seconds. The device is attached to the laboratory clock. Details may be obtained by communicating with the Standard Electric Time Company, Waterbury, Conn.

Mr. J. C. Riley presented a brief report for the committee on current literature.

Mr. A. H. Berry read a review of Gilley's Principles of Physics, presenting in a compact form the features of this book and calling especial attention to its indispensable value to teachers.

The members then went into the laboratory, where Mr. Charles E. Adams gave an exhibition and explanation of original diagrams and devices for use in teaching physics. Among many striking, simple, and instructive things the following deserve mention: (1) Transference of energy by vibration was illustrated by starting a wave of water at one end of a long sink, and as the wave struck the other end water flew out. It was also shown by shaking a clothesline in the way the coiled wire is usually shaken, but in this case a bell, attached at the end of the clothesline, was rung by the wave. (2) A sinusoidal curve was drawn on the blackboard by holding a piece of chalk in the hand and letting it form the curve as one walked alongside the board. Another "wave device" was walking along by a sheet hung from the ceiling—the sheet assumes a wave shape like that produced in the air by walking through it. (3) The entire subject of refraction was shown to the whole class

---

*** The galvanometer and balance are made by the Chicago Laboratory Supply and Scale Company.**

by one piece of apparatus consisting of a long tank (with glass sides), into which colored pieces of wood dipped. The tank was about six feet long, and when filled with water and supplied with the variously colored sticks it gave a vivid and convincing proof of refraction. (4) Telegraph and telephone diagrams made of colored paper and pasted on the wall showed how these subjects may be explained with ease. (5) A tabular statement of the difference between mass, volume, density, weight, and specific gravity illustrated in a concise form these confusing terms. (6) Diagrams illustrating the laws of falling and of rising bodies showed in a compact form the complete subject.

After lunch the members listened to an address on "The Life and Work of the Late Professor Henry A. Rowland," by Professor A. DeF. Palmer of Brown University, Providence, R. I. Professor Palmer was at one time a student and co-worker with Professor Rowland. The first part of the address was an interesting account of the early life and the personality of the distinguished scientist. Attention was called to the fact that his remarkable insight into scientific and mathematical subjects was shown early in his career. His notebooks made when a student and tutor are full of data which may in time furnish material for many important investigations. Mention was made of Professor Rowland's love for outdoor sports, especially hunting and sailing, and of his custom to spend Saturday afternoon in the pursuit of some agreeable pastime in the open air. His rapid manner of lecturing, his hatred of sham, his ardent love of truth, his willingness to acknowledge his own errors, his stupendous grasp of problems, his tireless labors, and marvelous results were all touched upon by the speaker. The second portion of the address was devoted to an exposition of the four important researches of Rowland, viz.: Magnetic permeability, electrical convection, mechanical equivalent of heat, concave gratings, and the solar spectrum. Each of these researches was explained by Professor Palmer by the aid of diagrams, formulas, or the original publications. A concave grating was shown, and also a portion of a large photograph of the solar spectrum made by a grating. Considerable time was devoted to a description of the engine by which the gratings were ruled, and to the method of photographing the solar spectrum, since it proved to be an intensely interesting subject to the members.

This address was followed by an exhibition of some lantern slides, showing the construction of the constant current transformers in use at the Salem (Mass.) electric light station. The views were explained by the Secretary, Mr. F. R. Hathaway. After a vote of thanks to Dr. H. P. Beckwith, Principal of the Salem Normal School, Mr. Adams, and Professor Palmer, the meeting adjourned and the members went to the electric light station to observe the operation of the transformers.

Reported by LYMAN C. NEWELL.

## NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The twelfth meeting of the Association was held in Boston, Mass., Saturday, November 23, 1901, at the Massachusetts Institute of Technology. There were about thirty members present. President R. P. Williams presided. Dr. H. G. Shaw of the Murdoch School, Winchendon, Mass., was elected secretary *pro tem*. The secretary's report of the previous meeting was adopted as printed—subject to corrections which might be made at the next meeting. Mr. Francis R. Hathaway, Salem, Mass., and Mr. F. Newton Black, Roxbury, Mass., were elected to associate membership—there being no vacancies on the active list. President Williams called attention felicitously to letters and a circular received from the Pacific Coast Association of Chemistry Teachers, and on a motion of Mr. Charles R. Allen the Secretary was directed to exchange publications with this and similar organizations, and to send all publications of the Association to prominent educators and the well known educational publications. The president likewise called attention to Benedict's Chemical Lecture Experiments (Macmillan), Newth's Chemical Lecture Experiments (Longmans, Green & Co.), and to Harcourt and Madan's Practical Chemistry (Clarendon Press). He also passed about for inspection a sample of the Atlas Tablets, a form of notebook adapted for laboratory notes in science. In the course of the meeting the president showed specimens of carborundum and artificial graphite obtained by him at the recent Pan-American Exposition.

Vice-President Albert C. Hale then addressed the Association on Pictet's method of obtaining oxygen gas on a large scale by means of liquid air. He stated very clearly the general principles of the liquefaction of gas, gave a brief account of Count Rumford and his connection with the Royal Institution at London, and referred, of course, to the preliminary work of Faraday and the later work of Dewar at that Institution. The principle on which Pictet's method is based is the well known one, viz., that liquid nitrogen boils at a lower temperature than liquid oxygen, and hence the nitrogen completely leaves a mixture of the two before the oxygen entirely evaporates. The speaker then gave a graphic account of some experiments which he saw Pictet perform, in which air was liquefied by forcing it by a bicycle pump through a tube immersed in liquid air contained in a Dewar bulb. With every stroke of the pump liquid air trickled down the immersed tube. Later experiments have shown that air around a tube of liquid air may itself be liquefied by exhausting the air from the inside of the tube of liquid air. By means of a diagram Dr. Hale showed the original process of Pictet for getting oxygen gas from liquid air. The details of this apparatus, as well as a statement of the process, may be found in the United States Patents Nos. 726,334 and 683,492. It is reported that the apparatus is able to produce 1,000,000 cubic feet of oxygen gas an hour at a cost of

one cent a cubic yard. The solid carbon dioxide which is incidentally produced is sold as a refrigerant and is said to yield a return sufficient to pay the operating expenses of the plant. The oxygen may be used, according to Pictet, to increase combustion at a decreased cost. No commercial use has yet been found for the nitrogen.

The general subject for discussion was "Chemical Experiments." Mr. James E. Downey of the Worcester (Mass.) Classical High School described the method used by his classes to determine the atomic weight and valence of zinc. The relation of zinc to hydrogen and to chlorine was found. From this experimentally-determined relation of zinc and chlorine, the formula of zinc chloride must be $ZnCl_2$ and not $ZnCl$ nor $ZnCl_3$, since $ZnCl_2$ is the only formula which agrees with the experimental evidence—the molecular weight of zinc chloride having been previously told the pupils. Since $ZnCl_2$ is the correct formula, the valence of zinc is two. Mr. Edward F. Holden of the Charlestown (Mass.) High School explained by a diagram a successful method of preparing sulphur trioxide. The sulphur dioxide, prepared by burning half a gram of sulphur in a deflagrating spoon in a bottle (2 or more liters) of oxygen, is drawn by an aspirator through three U tubes containing beads moistened with concentrated sulphuric acid and then through a hard glass tube 5 mm. in diameter containing a pinch of platinized asbestos; the sulphur trioxide passes into a fourth U tube attached to the hard glass tube and standing in a freezing mixture of ice and salt. Care must be taken to have all joints tight, and to use enough drying tubes to obtain a perfectly dry gas, otherwise the product will be a mere cloud and not the "frosty" solid. Mr. Charles H. Noyes of the Nashua (N. H.) High School gave an interesting account of the detection of "lactone," an artificial coloring matter used to make milk look "creamy." Sulphuric acid added to milk containing "lactone" produces a persistent pink color. Miss Emma H. Parker of the Newton (Mass.) High School outlined the plan of finding the atomic weight of zinc used by her classes. The subject of atomic weights naturally arose from the performance of several quantitative experiments. The relation of zinc to hydrogen, chlorine, and oxygen was found; that to hydrogen as usually, that to chlorine by weighing the residue obtained by dissolving a known weight of zinc in hydrochloric acid, and that to oxygen by heating to constant weight the residue obtained by dissolving a known weight of zinc in nitric acid. A determination of the specific heat of zinc by the usual method found in a textbook in physics settled the number to be chosen as the atomic weight. Mr. Wilhelm Segerblom of Phillips Academy, Exeter, N. H., described in detail the plan used by him to determine the composition (qualitatively) of nitric acid. Each constituent was detected by a series of connected experiments involving previous knowledge and compelling the pupil to rely on judgment as well as on experimental evidence. Miss Delia M. Stickney of the English High School, Cambridge, Mass., stated

briefly her plan of teaching self-reliance. Two classes are in the laboratory at the same time. One is assisted, while the other is set a task but given no assistance whatever. The pupils deprived of help soon learn that if the work is to be done it must be done by themselves. Dr. H. G. Shaw gave an extended account of the work done by his classes in chemistry after they have had enough preliminary work to acquire skill in manipulation. The usual experiment in neutralization is modified. Instead of using solutions of unknown strength, the pupil is given a solution of sulphuric acid of known strength which he titrates against a solution of sodium hydroxide (prepared by himself), and from his own results computes the weight of sodium hydroxide necessary to neutralize one gram of sulphuric acid. The laws of the conservation of matter, definite and multiple proportions, and the atomic theory are studied by the results of a series of quantitative experiments. A few preliminary experiments teach the general method of procedure. Then the molecular weight of potassium chlorate is calculated from results obtained by determining the loss of oxygen by heating, and from this molecular weight 48 is subtracted to get the molecular weight of potassium chloride. The molecular weight of silver nitrate is determined by titrating silver nitrate against potassium chloride, since from the actual weights of the reacting substances and the known molecular weight of potassium chloride (previously found) a simple proportion will give the molecular weight of silver nitrate. The results for silver nitrate vary from 167 to 173. The molecular weight of sodium chloride is found by titrating a solution of this salt against the silver nitrate solution and calculating as before. The results of this experiment show that in sodium chloride 40 per cent. is sodium and 60 per cent. is chlorine, and since the molecular weight of sodium chloride has already been found to be 58.5, it follows that the atomic weights of sodium and chlorine must be those parts of 58.5 which are in the ratio of 40 to 60—i. e., sodium equals 23 and chlorine equals 35.5. A previous experiment showed that silver chloride contains 75.28 per cent. of silver and 24.72 per cent. of chlorine, but since the atomic weight of chlorine has been found to be 35.5, then the atomic weight of silver by a simple proportion is about 108. If from the molecular weight of silver nitrate (previously found to be 170) we subtract 108 and 48 (the atomic weight of silver and the weight of 3 atoms of oxygen), the atomic weight of nitrogen is obtained as 14. The atomic weight of potassium is found by subtracting 35.5 from the molecular weight of potassium chloride.

After a vote of thanks to the Massachusetts Institute of Technology for the use of the room the meeting adjourned.

Reported by LYMAN C. NEWELL.

# Correspondence.

To the Editor:

In the April number (page 107) of School Science apparently two different answers are given to the question, (8) *"To what extent should the English of laboratory notes be corrected by the science teacher?"*

"Emphatically to no extent," the answer of "E. L. M.," is puzzling at first glance. If the writer means that the errors should not actually be corrected by the teacher, for the pupil, then we agree and would add that this seems almost axiomatic. Yet standing right after Mr. Mitchell's answer, that "the science teacher should note and correct errors," it makes him seem to say that he actually corrects the mistakes for the pupils, which he certainly did not mean. As Mr. Mitchell says, in the latter part of his statement, the errors should be constantly *pointed out* to the student.

Apropos of Professor Harvey's two classes in physics referred to in the abstract of his address before the Science Section of the N. E. A., and printed in School Science for September (page 180), it was clear that there was a hole in the fence somewhere, but I did not realize that it was to show more than neglected opportunity for training in the high school. From the correspondence in the October number (page 284) I see that the moral is much stronger—perverted training is worse than no training. Certainly all good science teachers will approve Professor Harvey's sentiments.

L M

Editor of School Science:

At about 8 o'clock of the evening of Oct. 27 occurred a very fine lunar bow, a description of which may be of interest to some of your readers.

The bow showed very distinctly on a light fleecy cloud through which the moon was shining. The colors appeared in the following order, beginning at the inside of the bow: Yellow, orange, red, violet, blue and green, and then these colors were repeated. The yellow, red and green were very bright, the other colors not showing so well. The bow appeared several times, within a few minutes, on successive clouds, as they passed in front of the moon.

Authorities say that these bows are due to the refraction of the light by ice crystals. In this case the cloud appeared to be an ordinary cloud. I have observed two such bows before and in each case there was no cloud as at this time, but simply a hazy appearance over the moon.

Weston, Oregon. Harry C. Doane.

## QUESTIONS FOR DISCUSSION.

**Teachers are invited to send in questions for discussion, as well as answers to the questions of others. "Be helpful and be helped."**

31. Will someone kindly give the proper strength permanganate solution for making wounds antiseptic? How far will this solution replace corrosive sublimate solution?

32. Is formaline a reliable disinfectant if used in vapor form?

33. In one of the newer elementary textbooks in botany a statement is made that would lead one to believe that yeast can act on starch. On the other hand textbooks commonly give the impression that yeast can act only on sugar. Will someone please give the literature that will answer these questions? Is it the ferment that changes the starch into some kind of sugar in the seed or flour, or does the yeast produce it?

34. Where can one obtain the sticks of Japanese incense for showing the path of rays of light, mentioned in Dr. Porter's experiment, in "Science," Oct. 11, 1901? It would be useful also for demonstrating currents in a room, in the study of hygiene.

35. Has any one else observed anything like the following: One of our students brought in a piece of a weed stem on which were six or seven little paddles of ice, the fluted stem of the weed being the shaft or axis of the little paddle wheel thus formed. The plates of ice were about 1/8 of an inch thick, 3/8 wide and 1½ inches long. An explanation will be welcome.